# AN ANALYSIS OF THE AQUATIC INVERTEBRATES AND HABITAT OF THE GALLATIN RIVER

**August 2000**



A report to

**The Montana Department of Environmental Quality**
**Helena, Montana**

by

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## INTRODUCTION

Aquatic invertebrates are aptly applied to bioassessment since they are known to be important indicators of stream ecosystem health (Hynes 1970). Long lives, complex life cycles and limited mobility mean that there is ample time for the benthic community to respond to cumulative effects of environmental perturbations.

This report summarizes data collected in August 2000 from six sites on the Gallatin River, Gallatin County, Montana, and compares data from two of the sites to data collected in 1998. Aquatic invertebrate assemblages were sampled by personnel of the Montana Department of Environmental Quality (DEQ). Study sites lie within the Middle Rockies ecoregion (Woods et al. 1999). A multimetric approach to bioassessment such as the one applied in this study uses attributes of the assemblage in an integrated way to measure biotic health. A stream with good biotic health is " ...a balanced, integrated, adaptive system having the full range of elements and processes that are expected in the region's natural environment..." (Karr and Chu 1999). The approach designed by Plafkin et al. (1989) and adapted for use in the State of Montana has been defined as "... an array of measures or metrics that individually provide information on diverse biological attributes, and when integrated, provide an overall indication of biological condition." (Barbour et al. 1995). Community attributes that can contribute meaningfully to interpretation of benthic data include assemblage structure, sensitivity of community members to stress or pollution, and functional traits. Each metric component contributes an independent measure of the biotic integrity of a stream site; combining the components into a total score reduces variance and increases precision of the assessment (Fore et al. 1995). Effectiveness of the integrated metrics depends on the applicability of the underlying model, which rests on a foundation of three essential elements (Bollman 1998). The first of these is an appropriate stratification or classification of stream sites, typically, by ecoregion. Second, metrics must be selected based upon their ability to accurately express biological condition. Third, an adequate assessment of habitat conditions at each site to be studied is needed to assist in the interpretation of metric outcomes.

Implicit in the multimetric method and its associated habitat assessment is an assumption of correlative relationships between habitat parameters and the biotic metrics, in the absence of water quality impairment. These relationships may vary regionally, requiring an examination of habitat assessment elements and biotic metrics and a test of the presumed relationship between them. Bollman (1998) has recently studied the assemblages of the Montana Valleys and Foothill Prairies ecoregion, and has recommended a battery of metrics applicable to the montane ecoregions of western Montana. This metric battery has been shown to be sensitive to impairment, related to habitat assessment parameters, and consistent over replicated samples.

Habitat assessment enhances the interpretation of biological data (Barbour and Stribling 1991), because there is generally a direct response of the biological community to habitat degradation in the absence of water quality impairment. If biotic health appears more damaged than the habitat quality would predict, water pollution by metals, other toxicants, high water temperatures, or high levels of organic and/or nutrient pollution might be suspected. On the other hand, an "artificial" elevation of biotic condition in the presence of habitat degradation may be due to the paradoxical effect of mild nutrient or organic enrichment in an oligotrophic setting.

## METHODS

Aquatic invertebrates were sampled by Montana DEQ personnel on August 21 and 22, 2000. Six sites on the Gallatin River were sampled. Site locations and sampling dates are indicated in Table 1. The sampling method employed was that recommended in the Montana Department of Environmental Quality (DEQ) Standard Operating Procedures for Aquatic Macroinvertebrate Sampling (Bukantis 1998). In addition to aquatic invertebrate sample collection, habitat quality was visually evaluated at each site and reported by means of the habitat assessment protocols recommended by Bukantis (1998) for streams with riffle/run prevalence.

Evaluated habitat features include instream conditions, larger-scale channel conditions including flow status, streambank condition, and extent of the riparian zone. Scores were assigned in the field to each habitat measure, and these scores were totaled and compared to the maximum possible score to give an overall assessment of habitat.

Aquatic invertebrate samples and associated habitat data were delivered to Rhithron Biological Associates, Missoula, Montana, for laboratory and data analyses.
In the laboratory, the Montana DEQ-recommended sorting method was used to obtain subsamples of at least 300 organisms from each sample, when possible. Organisms were identified to the lowest possible taxonomic levels consistent with Montana DEQ protocols.

To assess aquatic invertebrate communities in this study, a multimetric index developed in previous work for streams of western Montana ecoregions (Bollman 1998) was used. Multimetric indices result in a single numeric score, which integrates the values of several individual indicators of biologic health. Each metric used in this index was tested for its response or sensitivity to varying degrees of human influence. Correlations have been demonstrated between the metrics and various symptoms of human-caused impairment as expressed in water quality parameters or instream, streambank and stream reach morphologic features. Metrics were screened to minimize variability over natural environmental gradients, such as site elevation or sampling season, which might confound interpretation of results (Bollman 1998). The multimetric index used in this report incorporates multiple attributes of the sampled assemblage into an integrated score that accurately describes the benthic community of each site in terms of its biologic integrity. In addition to the metrics comprising the index, other metrics, which have been shown to be applicable to biomonitoring in other regions (Kleindl 1995, Patterson 1996, Rossano 1995) were used for descriptive interpretation of results. These metrics include the number of "clinger" taxa, long-lived taxa richness, the percent of predatory organisms, and others. They are not included in the integrated bioassessment score, however, since their performance in western Montana ecoregions is unknown. However, the relationship of these metrics to habitat conditions is intuitive and reasonable.

The six metrics comprising the bioassessment index used in this study were selected because both individually and as an integrated metric battery, they are robust at distinguishing impaired sites from relatively unimpaired sites (Bollman 1998). In addition, they are relevant to the kinds of impacts that are present on the Gallatin River. They have been demonstrated to be more variable with anthropogenic disturbance than with natural environmental gradients (Bollman 1998). Each of the six metrics developed and tested for western Montana ecoregions is described below.

**Table 1.** Sampling sites and dates. Six sites on the Gallatin River. 1998 and 2000. GPS readings are from the 2000 sampling season.

| Site designation | Sampling Dates | Location | GPS Latitude | GPS Longitude |
|---|---|---|---|---|
| G-1 | 8/21/2000 | Just downstream of Yellowstone Park boundary | 45°03'16" N | 111°09'23"W |
| G-2 | 8/21/2000 | Approx. ¾ mile below Taylor's Fork | 45°05'26" N | 111°12'46"W |
| G-3 | 10/23/1998<br>8/21/2000 | Above Porcupine Creek, above West Fork | 45°13'34" N | 111°14'57"W |
| G-4 | 10/23/1998<br>8/21/2000 | Near Jack Smith Bridge below West Fork confluence | 45°16'41" N | 111°14'44"W |
| G-5 | 8/22/2000 | Greek Creek Campground | 45°22'49" N | 111°11'03"W |
| G-6 | 8/22/2000 | 1 mile above Spanish Creek confluence | 45°28'28" N | 111°16'04"W |

1. **Ephemeroptera (mayfly) taxa richness.** The number of mayfly taxa declines as water quality diminishes. Impairments to water quality which have been demonstrated to adversely affect the ability of mayflies to flourish include elevated water temperatures, heavy metal contamination, increased turbidity, low or high pH, elevated specific conductance and toxic chemicals. Few mayfly species are able to tolerate certain disturbances to instream habitat, such as excessive sediment deposition.
2. **Plecoptera (stonefly) taxa richness.** Stoneflies are particularly susceptible to impairments that affect a stream on a reach-level scale, such as loss of riparian canopy, streambank instability, channelization, and alteration of morphological features such as pool frequency and function, riffle development and sinuosity. Just as all benthic organisms, they are also susceptible to smaller scale habitat loss, such as by sediment deposition, loss of interstitial spaces between substrate particles, or unstable substrate.
3. **Trichoptera (caddisfly) taxa richness.** Caddisfly taxa richness has been shown to decline when sediment deposition affects their habitat. In addition, the presence of certain case-building caddisflies can indicate good retention of woody debris and lack of scouring flow conditions.
4. **Number of sensitive taxa.** Sensitive taxa are generally the first to disappear as anthropogenic disturbances increase. The list of sensitive taxa used here includes organisms sensitive to a wide range of disturbances, including warmer water temperatures, organic or nutrient pollution, toxic pollution, sediment deposition, substrate instability and others. Unimpaired streams of western Montana typically support at least four sensitive taxa (Bollman 1998).

**5. Percent filter feeders.** Filter-feeding organisms are a diverse group; they capture small particles of organic matter, or organically enriched sediment material, from the water column by means of a variety of adaptations, such as silken nets or hairy appendages. In forested montane streams, filterers are expected to occur in insignificant numbers. Their abundance increases when canopy cover is lost and when water temperatures increase and the accompanying growth of filamentous algae occurs. Some filtering organisms, specifically the Arctopsychid caddisflies (*Arctopsyche* spp. and *Parapsyche* sp.) build silken nets with large mesh sizes that capture small organisms such as chironomids and early-instar mayflies. Here they are considered predators, and, in this study, their abundance does not contribute to the percent filter feeders metric.

**6. Percent tolerant taxa.** Tolerant taxa are ubiquitous in stream sites, but when disturbance increases, their abundance increases proportionately. The list of taxa used here includes organisms tolerant of a wide range of disturbances, including warmer water temperatures, organic or nutrient pollution, toxic pollution, sediment deposition, substrate instability and others.

Scoring criteria for each of the six metrics are presented in Table 2. Metrics differ in their possible value ranges as well as in the direction the values move as biological conditions change. For example, Ephemeroptera richness values may range from zero to ten taxa or higher. Larger values generally indicate favorable biotic conditions. On the other hand, the percent filterers metric may range from 0% to 100%; in this case, larger values are negative indicators of biotic health. To facilitate scoring, therefore, metric values were transformed into a single scale. The range of each metric has been divided into four parts and assigned a point score between zero and three. A score of three indicates a metric value similar to one characteristic of a non-impaired condition. A score of zero indicates strong deviation from non-impaired condition and suggests severe degradation of biotic health. Scores for each metric were summed to give an overall score, the total bioassessment score, for each site in each sampling event. These scores were expressed as the percent of the maximum possible score, which is 18 for this metric battery.

**Table 2.** Metrics and scoring criteria for bioassessment of streams of western Montana ecoregions (Bollman 1998).

| | *Score* | | | |
|---|---|---|---|---|
| *metric* | **3** | **2** | **1** | **0** |
| **Ephemeroptera taxa richness** | > 5 | 5 - 4 | 3 – 2 | < 2 |
| **Plecoptera taxa richness** | > 3 | 3 - 2 | 1 | 0 |
| **Trichoptera taxa richness** | > 4 | 4 - 3 | 2 | < 2 |
| **Sensitive taxa richness** | > 3 | 3 - 2 | 1 | 0 |
| **Percent filterers** | 0 – 5 | 5.01 - 10 | 10.01 – 25 | > 25 |
| **Percent tolerant taxa** | 0 – 5 | 5.01 - 10 | 10.01 – 35 | > 35 |

The total bioassessment score for each site was expressed in terms of use-support. Criteria for use-support designations were developed by Montana DEQ and are presented in

Table 3a. Scores were also translated into impairment classifications according to criteria outlined in Table 3b.

In this report, certain other metrics were used as descriptors of the benthic community response to habitat or water quality but were not incorporated into the bioassessment metric battery, either because they have not yet been tested for reliability in streams of western Montana, or because results of such testing did not show them to be robust at distinguishing impairment, or because they did not meet other requirements for inclusion in the metric battery. These metrics and their use in predicting the causes of impairment or in describing its effects on the biotic community are described below.

- The modified biotic index. This metric is an adaptation of the Hilsenhoff Biotic Index (HBI, Hilsenhoff 1987), which was originally designed to indicate organic enrichment of waters. Values of this metric are lowest in least impacted conditions. Taxa tolerant to saprobic conditions are also generally tolerant of warm water, fine sediment and heavy filamentous algae growth (Bollman, unpublished data). Loss of canopy cover is often a contributor to higher biotic index values. The taxa values used in this report are modified to reflect habitat and water quality conditions in Montana (Bukantis 1998). Ordination studies of the benthic fauna of Montana's foothill prairie streams showed that there is a correlation between modified biotic index values and water temperature, substrate embeddedness, and fine sediment (Bollman 1998). In a study of reference streams, the average value of the modified biotic index in least-impaired streams of western Montana was 2.5 (Wisseman 1992).
- Taxa richness. This metric is a simple count of the number of unique taxa present in a sample. Average taxa richness in samples from reference streams in western Montana was 28 (Wisseman 1992). Taxa richness is an expression of biodiversity, and generally decreases with degraded habitat or diminished water quality. However, taxa richness may show a paradoxical increase when mild nutrient enrichment occurs in previously oligotrophic waters, so this metric must be interpreted with caution.
- Percent predators. Aquatic invertebrate predators depend on a reliable source of invertebrate prey, and their abundance provides a measure of the trophic complexity supported by a site. Less disturbed sites have more plentiful habitat niches to support diverse prey species, which in turn support abundant predator species.
- Number of "clinger" taxa. So-called "clinger" taxa have physical adaptations that allow them to cling to smooth substrates in rapidly flowing water. Aquatic invertebrate "clingers" are sensitive to fine sediments that fill interstices between substrate particles and eliminate habitat complexity. Animals that occupy the hyporheic zones are included in this group of taxa. Expected "clinger" taxa richness in unimpaired streams of western Montana is at least 14 (Bollman, unpublished data).
- Number of long-lived taxa. Long-lived or semivoltine taxa require more than a year to completely develop, and their numbers decline when habitat and/or water quality conditions are unstable. They may completely disappear if channels are dewatered or if there are periodic water temperature elevations or other interruptions to their life cycles. Western Montana streams with stable habitat conditions are expected to support six or more long-lived taxa (Bollman, unpublished data).

| **Table 3a.** Criteria for the assignment of use-support classifications / standards violation thresholds (Bukantis, 1997). | |
|---|---|
| % Comparability to reference | Use support |
| >75 | Full support--standards not violated |
| 25-75 | Partial support--moderate impairment--standards violated |
| <25 | Non-support--severe impairment--standards violated |

| **Table 3b.** Criteria for the assignment of impairment classifications (Plafkin et al. 1989). | |
|---|---|
| % Comparability to reference | Classification |
| > 83 | nonimpaired |
| 54-79 | slightly impaired |
| 21-50 | moderately impaired |
| <17 | severely impaired |

**RESULTS**

***Habitat assessment***

Figure 1 compares habitat assessment results for the 6 sites visited. Table 4 itemizes the evaluated habitat parameters and shows the assigned scores for each.

**Figure 1.** Total habitat assessment scores for six sites on the Gallatin River. August 2000.

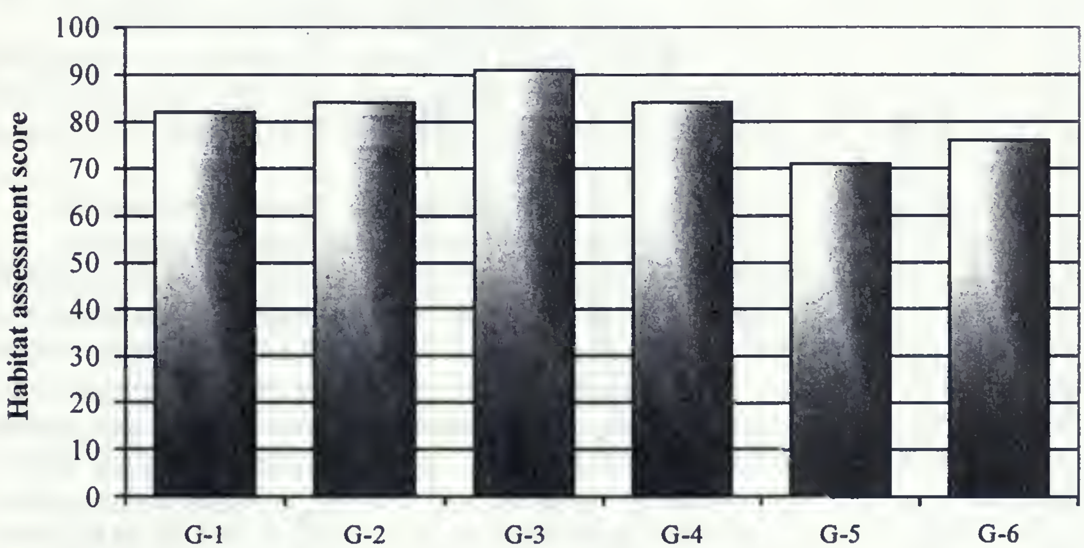


**Table 4.** Stream and riparian habitat assessment. Six sites on the Gallatin River. August 2000.

| Max. possible score | Parameter | G-1 | G-2 | G-3 | G-4 | G-5 | G-6 |
|---|---|---|---|---|---|---|---|
| 10 | Riffle development | 10 | 10 | 10 | 10 | 9 | 10 |
| 10 | Benthic substrate | 10 | 10 | 7 | 7 | 9 | 7 |
| 20 | Embeddedness | 17 | 19 | 19 | 18 | 16 | 16 |
| 20 | Channel alteration | 19 | 18 | 19 | 20 | 16 | 18 |
| 20 | Sediment deposition | 12 | 15 | 19 | 11 | 16 | 17 |
| 20 | Channel flow status | 19 | 17 | 15 | 15 | 12 | 15 |
| 20 | Bank stability: left / right | 8 / 10 | 7 / 8 | 10 / 10 | 8 / 7 | 1 / 3 | 6 / 1 |
| 20 | Bank vegetation: left / right | 9 / 9 | 9 / 9 | 9 / 10 | 9 / 10 | 8 / 6 | 7 / 6 |
| 20 | Vegetated zone: left / right | 4 / 4 | 6 / 7 | 8 / 10 | 10 / 10 | 9 / 9 | 9 / 9 |
| 160 | Total | 131 | 135 | 146 | 135 | 114 | 121 |
| | Percent of maximum | **82** | **84** | **91** | **84** | **71** | **76** |
| | CONDITION* | **OPT** | **OPT** | **OPT** | **OPT** | **SUB** | **SUB** |

*Condition categories: Optimal (OPT) > 80% of maximum score; Sub-optimal (SUB) ; 75 - 56%; Marginal (MARG) 49 - 29%; Poor <23%. Adapted from Plafkin et al. 1998

Habitat assessment scores generally diminished in a downstream direction. From the Yellowstone Park Boundary (G-1) downstream to the Jack Smith Bridge (G-4), the 4 visited sites were perceived to have optimal habitat. At the Greek Creek Campground (G-5) downstream to the site above Spanish Creek (G-6), scores indicated sub-optimal habitat.

Near Yellowstone Park (G-1), the riparian zone width on both sides of the Gallatin River channel was judged marginal, with willows limited to narrow clusters. Instream parameters scored optimally, although benthic substrate was composed of monotonous cobble-sized particles. Near Taylor's Fork (G-2), streambank stability was rated sub-optimal, and the riparian zone was perceived to be somewhat abbreviated.

Above Porcupine Creek (G-3), sand and silt were noted among the cobbles comprising the benthic substrate; this parameter was judged sub-optimal. Flow was apparently somewhat diminished, with some of the wetted width exposed, probably due to drought conditions in 2000. Some encroachment of human developments reduced the riparian zone width on one side of the channel.

Sand and silt deposits, along with minor formation of new bars were noted near the Jack Smith Bridge (G-4). Accelerated erosion along streambanks was attributed to recreational use at this site. Channel flow status was perceived to be sub-optimal.

Major problems with eroding streambanks were noted at the Greek Creek Campground (G-5); the silt observed in the channel at the site was probably associated with these unstable banks. Dewatering was evident and was attributed to drought.

Abundant silt and unstable streambanks were noted at the lowermost site (G-6), however, instability was attributed to a natural scree slope along one side of the channel at this site.

*Bioassessment*

Figure 2 summarizes bioassessment scores for aquatic invertebrate communities sampled at the six sites in this study. Table 5 itemizes each contributing metric and shows individual metric scores for each site. Tables 3a and 3b show criteria for impairment classifications and use-support categories recommended by Montana DEQ.

When this bioassessment method is applied to these data, all Gallatin River sites in both years appear to be essentially unimpaired and fully support their designated uses. Sixty-nine percent (33 of 48) of the individual metric calculations performed for this study resulted in optimal scores. Results from 1998 did not differ substantially from 2000 for sites G-3 and G-4.

*Aquatic invertebrate communities*

Although scores indicate unimpaired biotic communities at all studied sites, subtle differences can be discerned between sites above the Jack Smith Bridge (G-1, G-2, G-3) when compared to the sites downstream of that location (G-4, G-5, G-6). Mean modified biotic index scores for sites above the Jack Smith Bridge are significantly lower than those for sites downstream ($p = .0075$), suggesting that water quality diminishes in a downstream direction. In addition, taxa richness increases in a downstream direction, perhaps illustrating the "nutrient paradox" concept described earlier in this report. The proportion of midges in samples increases dramatically between sites G-3 and G-4, but drops off again at site G-6. These findings are moderated by the fact that biotic index scores throughout the sampled reach of the Gallatin River are within the limits expected for unimpaired montane streams, and increased taxa richness at the

**Figure 2.** Total bioassessment scores for six sites on the Gallatin River. Sites are described in Table 1. Sites G-3 and G-4 were evaluated in both 1998 and 2000. Revised bioassessment metric battery and criteria (Bollman 1998) used as reference.

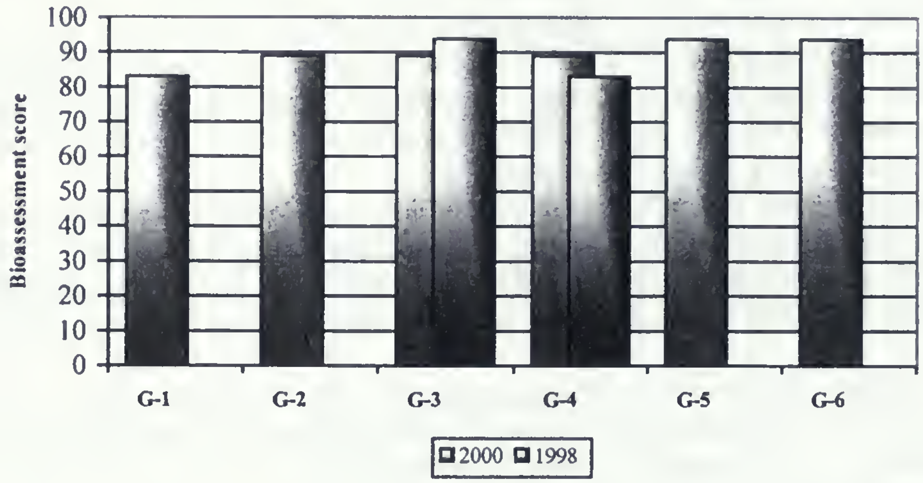



**Table 5.** Metric values, scores, and bioassessments for six sites on the Gallatin River. August 2000. Sites are described in Table 1. Revised bioassessment metric battery and criteria (Bollman 1998) used as reference.

| | SITES | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Year** | 2000 | | | | | | 1998 | |
| | G-1 | G-2 | G-3 | G-4 | G-5 | G-6 | G-3 | G-4 |
| **METRICS** | **METRIC VALUES** | | | | | | | |
| **Ephemeroptera richness** | 9 | 6 | 5 | 6 | 6 | 8 | 6 | 5 |
| **Plecoptera richness** | 3 | 3 | 4 | 3 | 6 | 5 | 4 | 4 |
| **Trichoptera richness** | 4 | 5 | 7 | 5 | 5 | 5 | 8 | 5 |
| **Number of sensitive taxa** | 2 | 3 | 3 | 2 | 5 | 4 | 4 | 3 |
| **Percent filterers** | 3 | 3 | 3 | 5 | 6 | 4 | 5 | 6 |
| **Percent tolerant taxa** | 0 | 2 | 2 | 3 | 1 | 6 | 1 | 5 |
| | **METRIC SCORES** | | | | | | | |
| **Ephemeroptera richness** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 2 |
| **Plecoptera richness** | 2 | 2 | 3 | 2 | 3 | 3 | 3 | 3 |
| **Trichoptera richness** | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **Number of sensitive taxa** | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 2 |
| **Percent filterers** | 3 | 3 | 3 | 3 | 2 | 3 | 2 | 2 |
| **Percent tolerant taxa** | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 |
| **TOTAL SCORE (max.=18)** | 15 | 16 | 16 | 16 | 17 | 17 | 17 | 15 |
| **PERCENT OF MAX.** | **83** | **89** | **89** | **89** | **94** | **94** | **94** | **83** |
| **Impairment classification*** | NON | NON | NON | NON | NON | NON | NON | NON |
| **USE SUPPORT †** | FULL | FULL | FULL | FULL | FULL | FULL | FULL | FULL |

* Classifications: (NON) non-impaired, (SLI) slightly impaired, (MOD) moderately impaired, (SEV) severely impaired. See Table 3a. † Use support designations: See Table 3b.

lower sites is moderate. However, the results could be interpreted as evidence that nutrient availability in the river may increase longitudinally within the reach.

Samples collected at the 2 uppermost sites (G-1 and G-2) yielded only 3 stonefly taxa apiece. Low stonefly taxa richness can be associated with reach-scale habitat shortcomings, such as loss of riparian function or streambank instability. At site G-2, the stonefly fauna included the sensitive salmonfly *Pteronarcys californica*, suggesting that human disturbances within the reach were minimal. Sediment deposition did not appear to impair community integrity, since 13 "clinger" taxa were collected at G-1 and 12 at G-2. The assemblage collected at G-3 is characteristic of an unimpaired montane stream; all appropriate functional components of a healthy community are represented.

At G-4, near the Jack Smith Bridge, midges comprised 30% of the sampled organisms, and the modified biotic index (2.77) was elevated compared to the upstream sites ($\mu = 1.56$) suggesting mildly diminished water quality. Only 3 stonefly taxa were present in the sample, suggesting reach scale habitat disturbances or shortcomings. The stonefly fauna at this site included 2 sensitive taxa, *Cultus* sp., and *Pteronarcys californica*, implying that disturbances, if any, were minimal.

Despite the mildly elevated modified biotic index value (2.10), the assemblage collected at G-5 included representatives from all appropriate functional groups. High richness scores for the 3 critical insect orders (mayflies, stoneflies, and caddisflies) implied adequately good water quality and unimpaired large and small habitat components. The slight increase of the proportion of filter-feeders over expectations suggests that increased nutrient concentrations were accompanied by slightly increased abundance of fine organic particles in suspension. Filter-feeders at the site were entirely comprised of populations of the blackfly *Simulium* sp. and the net-spinning caddisfly *Hydropsyche* sp.; both of these animals are characteristic opportunists when nutrients increase in montane stream environments.

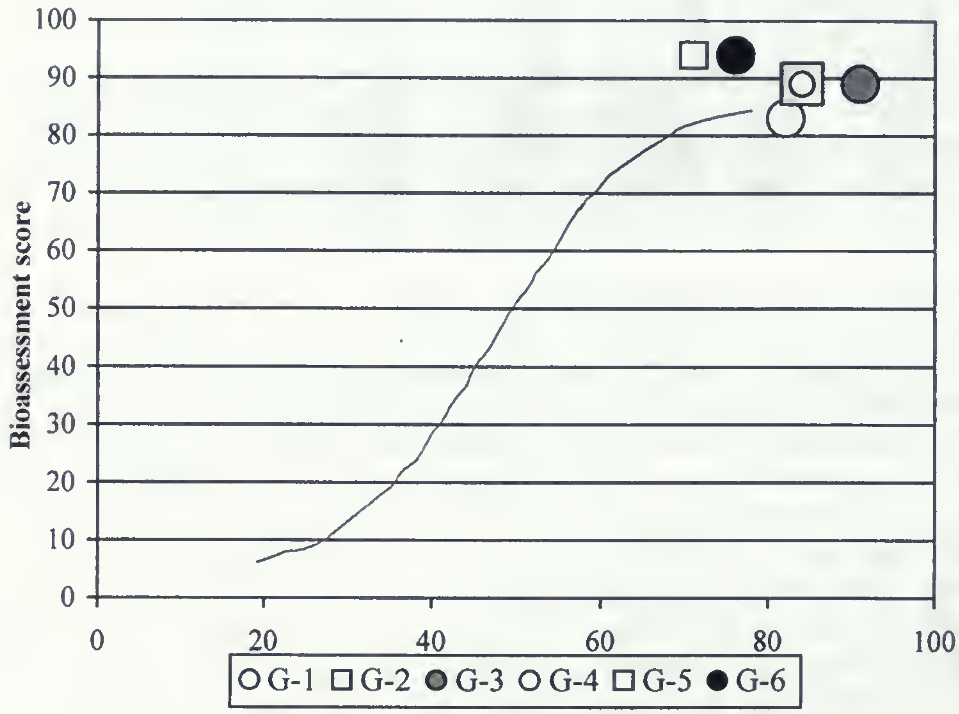
Good habitat conditions and good water quality appear to persist at the most downstream site visited on the Gallatin River (G-6), despite the slightly elevated biotic index (2.50). Functional composition was appropriate to an unimpaired mountain stream, and abundant "clinger" taxa (17) suggested that instream habitats were essentially unimpacted by sediment deposition.

## CONCLUSIONS

- Subtle evidence of increased nutrient pollution below the Jack Smith Bridge can be detected in the taxonomic composition and biotic index values of collected assemblages. Water quality appears to remains high in all sampled reaches of the Gallatin River, despite these findings.
- Good habitat conditions at all visited sites supports biotic communities essentially unimpaired by human disturbances.
- The relationship between habitat assessment scores and bioassessment scores is illustrated in Figure 3. The red curve in the center of the graph represents the hypothetical relationship between habitat quality and biotic health when habitat degradation is the sole source of impairment to benthic assemblage health (Barbour and Stribling 1991). The cluster of data points in the upper right corner of the graph implies that all sites in the

study had a combination of minimally disturbed habitat and minimally degraded water quality.

- **Figure 3.** The relationship of habitat assessment scores and bioassessment scores for sites on the Gallatin River, August 2000. The red curve represents the hypothetical relationship between habitat scores and bioassessment scores if habitat quality solely determined biotic health.



## LITERATURE CITED


Barbour, M.T., J.B. Stribling and J.R. Karr. 1995. Multimetric approach for establishing biocriteria and measuring biological condition. Pages 63-79 in W.S. Davis and T.P. Simon (editors) *Biological Assessment and Criteria: Tools for Water Resource Planning and Decision Making.* Lewis Publishers, Boca Raton.

Barbour, M.T. and J.B. Stribling. 1991. Use of habitat assessment in evaluating the biological integrity of stream communities. In: *Biological Criteria: Research and Regulation.* Proceedings of a Symposium, 12-13 December 1990, Arlington, Virginia. EPA-440-5-91-005. U.S. Environmental Protection Agency, Washington, DC.

Bollman, W. 1998. Improving Stream Bioassessment Methods for the Montana Valleys and Foothill Prairies Ecoregion. Unpublished Master's Thesis. University of Montana. Missoula, Montana.

Bukantis, R. 1997. Rapid bioassessment macroinvertebrate protocols: Sampling and sample analysis SOP's. Working draft, April 22, 1997. Montana Department of Environmental Quality. Planning Prevention and Assistance Division. Helena, Montana.

Fore, L.S., J.R. Karr and L.L. Conquest. 1995. Statistical properties of an index of biological integrity used to evaluate water resources. *Canadian Journal of Fisheries and Aquatic Sciences.* 51: 1077-1087.

Fore, L.S., J.R. Karr and R.W. Wisseman. 1996. Assessing invertebrate responses to human activities: evaluating alternative approaches. *Journal of the North American Benthological Society* 15(2): 212-231.

Gauch, H. G. 1982. *Multivariate Analysis in Community Ecology.* Cambridge University Press. Cambridge.

Hilsenhoff, W.L. 1987. An improved biotic index of organic stream pollution. *Great Lakes Entomologist.* 20: 31-39.

Hynes, H.B.N. 1970. *The Ecology of Running Waters.* The University of Toronto Press. Toronto.

Karr, J.R., and E. W. Chu. 1999. *Restoring Life in Running Water: better biological monitoring.* Island Press. Washington, DC.

Kleindl, W.J. 1995. A benthic index of biotic integrity for Puget Sound Lowland Streams, Washington, USA. Unpublished Master's Thesis. University of Washington, Seattle, Washington.

Omernik, J.M. 1997. Level III-Level IV ecoregions of Montana. Unpublished First Draft. August, 1997.

Patterson, A.J. 1996. The effect of recreation on biotic integrity of small streams in Grand Teton National Park. Unpublished Master's Thesis. University of Washington, Seattle, Washington.

Plafkin, J.L., M.T. Barbour, K.D. Porter, S.K. Gross and R.M.Hughes. 1989. Rapid Bioassessment Protocols for Use in Streams and Rivers. Benthic Macroinvertebrates and Fish. EPA 440-4-89-001. Office of Water Regulations and Standards, U.S. Environmental Protection Agency, Washington, D.C.

Rossano, E.M. 1995. Development of an index of biological integrity for Japanese streams (IBI-J). Unpublished Master's Thesis. University of Washington, Seattle, Washington.

Wisseman, R.W. 1992. Montana rapid bioassessment protocols. Benthic invertebrate studies, 1990. Montana Reference Streams study. Report to the Montana Department of Environmental Quality. Water Quality Bureau. Helena, Montana.

Woods, A.J., Omernik, J. M. Nesser, J.A., Shelden, J., and Azevedo, S. H. 1999. Ecoregions of Montana. *(Poster).* Reston, Virginia. USGS.

APPENDIX

Taxonomic data and summaries

The Gallatin River

August 2000

**Aquatic Invertebrate Taxonomic Data**

**Site Name: Gallatin River**
**Site ID: G-1 8/21/2000**

Approx. percent of sample used: 17

| Taxon | Quantity | Percent | HBI | FFG |
|---|---|---|---|---|
| Tubificidae - immature | 1 | 0.29 | 9 | CG |
| **Total Misc. Taxa** | **1** | **0.29** | | |
| *Acentrella turbida* | 1 | 0.29 | 4 | CG |
| *Drunella doddsi* | 27 | 7.94 | 0 | CG |
| *Drunella grandis* | 13 | 3.82 | 2 | CG |
| *Ephemerella* sp. | 3 | 0.88 | 1 | CG |
| *Serratella tibialis* | 3 | 0.88 | 2 | CG |
| *Cinygmula* sp. | 3 | 0.88 | 4 | SC |
| *Epeorus albertae* | 4 | 1.18 | 1 | SC |
| *Epeorus longimanus* | 1 | 0.29 | 1 | SC |
| *Rhithrogena* sp. | 6 | 1.76 | 0 | SC |
| **Total Ephemeroptera** | **61** | **17.94** | | |
| *Sweltsa* sp. | 1 | 0.29 | 1 | PR |
| *Hesperoperla pacifica* | 2 | 0.59 | 2 | PR |
| *Skwala* sp. | 2 | 0.59 | 2 | PR |
| **Total Plecoptera** | **5** | **1.47** | | |
| *Arctopsyche grandis* | 5 | 1.47 | 1 | PR |
| *Brachycentrus americanus* | 13 | 3.82 | 1 | OM |
| *Brachycentrus occidentalis* | 26 | 7.65 | 1 | OM |
| *Glossosoma* sp. | 173 | 50.88 | 1 | SC |
| **Total Trichoptera** | **217** | **63.82** | | |
| *Simulium* sp. | 10 | 2.94 | 6 | CF |
| *Hexatoma* sp. | 1 | 0.29 | 2 | PR |
| **Total Diptera** | **11** | **3.24** | | |
| *Cricotopus nostococladius* | 9 | 2.65 | 3 | PH |
| Eukiefferiella Devonica Gr. | 1 | 0.29 | 4 | OM |
| Eukiefferiella Gracei Gr. | 17 | 5.00 | 4 | OM |
| *Micropsectra* sp. | 1 | 0.29 | 7 | CG |
| *Orthocladius* sp. | 6 | 1.76 | 6 | CG |
| *Pagastia* sp. | 4 | 1.18 | 1 | CG |
| *Tvetenia* sp. | 7 | 2.06 | 5 | CG |
| **Total Chironomidae** | **45** | **13.24** | | |
| **Grand Total** | **340** | **100.00** | | |

**Aquatic Invertebrate Summary Data**

**Site Name: Gallatin River** **Site ID: G-1 8/21/2000**

| | |
|---|---|
| TOTAL ABUNDANCE | 340 |
| Ephemeroptera + Plecoptera + Trichoptera (EPT) abundance | 283 |
| TOTAL NUMBER OF TAXA | 26 |
| Number EPT taxa | 16 |

TAXONOMIC GROUP COMPOSITION

| GROUP | #TAXA | ABUNDAN | PERCENT |
|---|---|---|---|
| Misc. Taxa | 1 | 1 | 0.29 |
| Odonata | 0 | 0 | 0.00 |
| Ephemeroptera | 9 | 61 | 17.94 |
| Plecoptera | 3 | 5 | 1.47 |
| Hemiptera | 0 | 0 | 0.00 |
| Megaloptera | 0 | 0 | 0.00 |
| Trichoptera | 4 | 217 | 63.82 |
| Lepidoptera | 0 | 0 | 0.00 |
| Coleoptera | 0 | 0 | 0.00 |
| Diptera | 2 | 11 | 3.24 |
| Chironomidae | 7 | 45 | 13.24 |

RATIOS OF TAX GROUP ABUNDANCES

| | |
|---|---|
| EPT/Chironomidae | 6.29 |

FUNCTIONAL FEEDING GROUP (FFG) COMPOSITION

| GROUP | #TAXA | ABUNDAN | PERCENT |
|---|---|---|---|
| Predator | 5 | 11 | 3.24 |
| Parasite | 0 | 0 | 0.00 |
| Collector-gatherer | 10 | 66 | 19.41 |
| Collector-filterer | 1 | 10 | 2.94 |
| Macrophyte-herbivore | 0 | 0 | 0.00 |
| Piercer-herbivore | 1 | 9 | 2.65 |
| Scraper | 5 | 187 | 55.00 |
| Shredder | 0 | 0 | 0.00 |
| Xylophage | 0 | 0 | 0.00 |
| Omnivore | 4 | 57 | 16.76 |
| Unknown | 0 | 0 | 0.00 |

RATIOS OF FFG ABUNDANCES

| | |
|---|---|
| Scraper/Collector-filterer | 18.70 |
| Scraper/(Scraper + C.filterer) | 0.95 |
| Shredder/Total organisms | 0.00 |

CONTRIBUTION OF DOMINANT TAXA

| TAXON | ABUNDANCE | PERCENT |
|---|---|---|
| *Glossosoma* sp. | 173 | 50.88 |
| *Drunella doddsi* | 27 | 7.94 |
| *Brachycentrus occidentalis* | 26 | 7.65 |
| Eukiefferiella Gracei Gr. | 17 | 5.00 |
| *Drunella grandis* | 13 | 3.82 |
| SUBTOTAL 5 DOMINANTS | 256 | 75.29 |
| *Brachycentrus americanus* | 13 | 3.82 |
| *Simulium* sp. | 10 | 2.94 |
| *Cricotopus nostococladius* | 9 | 2.65 |
| *Tvetenia* sp. | 7 | 2.06 |
| *Rhithrogena* sp. | 6 | 1.76 |
| TOTAL DOMINANTS | 301 | 88.53 |

SAPROBIC INDICES

| | |
|---|---|
| Hilsenhoff Biotic Index | 1.57 |

DIVERSITY MEASURES

| | |
|---|---|
| Shannon H (loge) | 2.04 |
| Shannon H (log2) | 2.94 |
| Evenness | 0.62 |
| Simpson D | 0.28 |

COMMUNITY VOLTINISM ANALYSIS

| TYPE | ABUNDANCE | PERCENT |
|---|---|---|
| Multivoltine | 35 | 10.15 |
| Univoltine | 260 | 76.32 |
| Semivoltine | 46 | 13.53 |

| | #TAXA | ABUNDANCE | PERCENT |
|---|---|---|---|
| Tolerant | 0 | 0 | 0.00 |
| Intolerant | 2 | 36 | 10.59 |
| Clinger | 13 | 287 | 84.41 |

**Aquatic Invertebrate Taxonomic Data**

**Site Name: Gallatin River**

**Site ID: G-2 8/21/2000**

Approx. percent of sample used: 23

| Taxon | Quantity | Percent | HBI | FFG |
|---|---|---|---|---|
| *Baetis tricaudatus* | 8 | 2.42 | 6 | CG |
| *Drunella doddsi* | 77 | 23.33 | 0 | CG |
| *Drunella grandis* | 2 | 0.61 | 2 | CG |
| *Serratella tibialis* | 3 | 0.91 | 2 | CG |
| *Epeorus longimanus* | 4 | 1.21 | 1 | SC |
| *Rhithrogena* sp. | 5 | 1.52 | 0 | SC |
| **Total Ephemeroptera** | **99** | **30.00** | | |
| *Hesperoperla pacifica* | 1 | 0.30 | 2 | PR |
| *Skwala* sp. | 2 | 0.61 | 2 | PR |
| *Pteronarcys californica* | 3 | 0.91 | 1 | OM |
| **Total Plecoptera** | **6** | **1.82** | | |
| *Arctopsyche grandis* | 6 | 1.82 | 1 | PR |
| *Brachycentrus americanus* | 19 | 5.76 | 1 | OM |
| *Brachycentrus occidentalis* | 2 | 0.61 | 1 | OM |
| *Glossosoma* sp. | 164 | 49.70 | 1 | SC |
| *Hydropsyche* sp. | 3 | 0.91 | 4 | CF |
| **Total Trichoptera** | **194** | **58.79** | | |
| *Atherix* sp. | .4 | 1.21 | 4 | PR |
| *Agathon* sp. | 10 | 3.03 | 0 | SC |
| *Simulium* sp. | 8 | 2.42 | 6 | CF |
| **Total Diptera** | **22** | **6.67** | | |
| *Cricotopus nostococladius* | 6 | 1.82 | 3 | PH |
| Eukiefferiella Gracei Gr. | 1 | 0.30 | 4 | OM |
| *Tvetenia* sp. | 2 | 0.61 | 5 | CG |
| **Total Chironomidae** | **9** | **2.73** | | |
| **Grand Total** | **330** | **100.00** | | |

**Aquatic Invertebrate Summary Data**

**Site Name: Gallatin River** **Site ID: G-2 8/21/2000**

| | |
|---|---|
| TOTAL ABUNDANCE | 330 |
| Ephemeroptera + Plecoptera + Trichoptera (EPT) abundance | 299 |
| TOTAL NUMBER OF TAXA | 20 |
| Number EPT taxa | 14 |

TAXONOMIC GROUP COMPOSITION

| GROUP | #TAXA | ABUNDAN | PERCENT |
|---|---|---|---|
| Misc. Taxa | 0 | 0 | 0.00 |
| Odonata | 0 | 0 | 0.00 |
| Ephemeroptera | 6 | 99 | 30.00 |
| Plecoptera | 3 | 6 | 1.82 |
| Hemiptera | 0 | 0 | 0.00 |
| Megaloptera | 0 | 0 | 0.00 |
| Trichoptera | 5 | 194 | 58.79 |
| Lepidoptera | 0 | 0 | 0.00 |
| Coleoptera | 0 | 0 | 0.00 |
| Diptera | 3 | 22 | 6.67 |
| Chironomidae | 3 | 9 | 2.73 |

RATIOS OF TAX GROUP ABUNDANCES

| | |
|---|---|
| EPT/Chironomidae | 33.22 |

FUNCTIONAL FEEDING GROUP (FFG) COMPOSITION

| GROUP | #TAXA | ABUNDAN | PERCENT |
|---|---|---|---|
| Predator | 4 | 13 | 3.94 |
| Parasite | 0 | 0 | 0.00 |
| Collector-gatherer | 5 | 92 | 27.88 |
| Collector-filterer | 2 | 11 | 3.33 |
| Macrophyte-herbivore | 0 | 0 | 0.00 |
| Piercer-herbivore | 1 | 6 | 1.82 |
| Scraper | 4 | 183 | 55.45 |
| Shredder | 0 | 0 | 0.00 |
| Xylophage | 0 | 0 | 0.00 |
| Omnivore | 4 | 25 | 7.58 |
| Unknown | 0 | 0 | 0.00 |

RATIOS OF FFG ABUNDANCES

| | |
|---|---|
| Scraper/Collector-filterer | 16.64 |
| Scraper/(Scraper + C.filterer) | 0.94 |
| Shredder/Total organisms | 0.00 |

CONTRIBUTION OF DOMINANT TAXA

| TAXON | ABUNDANCE | PERCENT |
|---|---|---|
| *Glossosoma* sp. | 164 | 49.70 |
| *Drunella doddsi* | 77 | 23.33 |
| *Brachycentrus americanus* | 19 | 5.76 |
| *Agathon* sp. | 10 | 3.03 |
| *Baetis tricaudatus* | 8 | 2.42 |
| SUBTOTAL 5 DOMINANTS | 278 | 84.24 |
| *Simulium* sp. | 8 | 2.42 |
| *Arctopsyche grandis* | 6 | 1.82 |
| *Cricotopus nostocodadius* | 6 | 1.82 |
| *Rhithrogena* sp. | 5 | 1.52 |
| TOTAL DOMINANTS | 303 | 91.82 |

SAPROBIC INDICES

| | |
|---|---|
| Hilsenhoff Biotic Index | 1.12 |

DIVERSITY MEASURES

| | |
|---|---|
| Shannon H (loge) | 1.74 |
| Shannon H (log2) | 2.51 |
| Evenness | 0.58 |
| Simpson D | 0.31 |

COMMUNITY VOLTINISM ANALYSIS

| TYPE | ABUNDANCE | PERCENT |
|---|---|---|
| Multivoltine | 14 | 4.09 |
| Univoltine | 286 | 86.52 |
| Semivoltine | 31 | 9.39 |

| | #TAXA | ABUNDANCE | PERCENT |
|---|---|---|---|
| Tolerant | 1 | 8 | 2.42 |
| Intolerant | 3 | 93 | 28.18 |
| Clinger | 12 | 296 | 89.70 |

**Aquatic Invertebrate Taxonomic Data**

**Site Name: Gallatin River**
**Site ID: G-3 8/21/2000**

Approx. percent of sample used: 83

| **Taxon** | **Quantity** | **Percent** | **HBI** | **FFG** |
|---|---|---|---|---|
| Tubificidae - immature | 7 | 2.08 | 9 | CG |
| **Total Misc. Taxa** | **7** | **2.08** | | |
| *Baetis tricaudatus* | 2 | 0.60 | 6 | CG |
| *Drunella doddsi* | 32 | 9.52 | 0 | CG |
| *Drunella grandis* | 23 | 6.85 | 2 | CG |
| *Serratella tibialis* | 24 | 7.14 | 2 | CG |
| *Rhithrogena* sp. | 7 | 2.08 | 0 | SC |
| **Total Ephemeroptera** | **88** | **26.19** | | |
| *Sweltsa* sp. | 1 | 0.30 | 1 | PR |
| *Hesperoperla pacifica* | 19 | 5.65 | 2 | PR |
| *Skwala* sp. | 8 | 2.38 | 2 | PR |
| *Pteronarcys californica* | 5 | 1.49 | 1 | OM |
| **Total Plecoptera** | **33** | **9.82** | | |
| *Arctopsyche grandis* | 5 | 1.49 | 1 | PR |
| *Brachycentrus americanus* | 11 | 3.27 | 1 | OM |
| *Glossosoma* sp. | 89 | 26.49 | 1 | SC |
| *Hydropsyche* sp. | 11 | 3.27 | 4 | CF |
| *Lepidostoma* sp.-sand case larvae | 1 | 0.30 | 1 | SH |
| *Apatania* sp. | 6 | 1.79 | 1 | SC |
| *Rhyacophila* sp.-early instar | 1 | 0.30 | 0 | PR |
| **Total Trichoptera** | **124** | **36.90** | | |
| *Optioservus* sp. | 4 | 1.19 | 4 | SC |
| **Total Coleoptera** | **4** | **1.19** | | |
| *Atherix* sp. | 11 | 3.27 | 4 | PR |
| *Hexatoma* sp. | 23 | 6.85 | 2 | PR |
| **Total Diptera** | **34** | **10.12** | | |
| *Cricotopus brevipalpus* | 2 | 0.60 | 7 | CG |
| *Cricotopus nostococladius* | 25 | 7.44 | 3 | PH |
| Eukiefferiella Brehmi Gr. | 1 | 0.30 | 4 | OM |
| *Orthocladius* sp. | 10 | 2.98 | 6 | CG |
| *Pagastia* sp. | 3 | 0.89 | 1 | CG |
| *Tvetenia* sp. | 5 | 1.49 | 5 | CG |
| **Total Chironomidae** | **46** | **13.69** | | |
| **Grand Total** | **336** | **100.00** | | |

**Aquatic Invertebrate Summary Data**

**Site Name: Gallatin River** **Site ID: G-3 8/21/2000**

| | |
|---|---|
| TOTAL ABUNDANCE | 336 |
| Ephemeroptera + Plecoptera + Trichoptera (EPT) abundance | 245 |
| TOTAL NUMBER OF TAXA | 26 |
| Number EPT taxa | 16 |

TAXONOMIC GROUP COMPOSITION

| GROUP | #TAXA | ABUNDAN | PERCENT |
|---|---|---|---|
| Misc. Taxa | 1 | 7 | 2.08 |
| Odonata | 0 | 0 | 0.00 |
| Ephemeroptera | 5 | 88 | 26.19 |
| Plecoptera | 4 | 33 | 9.82 |
| Hemiptera | 0 | 0 | 0.00 |
| Megaloptera | 0 | 0 | 0.00 |
| Trichoptera | 7 | 124 | 36.90 |
| Lepidoptera | 0 | 0 | 0.00 |
| Coleoptera | 1 | 4 | 1.19 |
| Diptera | 2 | 34 | 10.12 |
| Chironomidae | 6 | 46 | 13.69 |

RATIOS OF TAX GROUP ABUNDANCES

| | |
|---|---|
| EPT/Chironomidae | 5.33 |

FUNCTIONAL FEEDING GROUP (FFG) COMPOSITION

| GROUP | #TAXA | ABUNDAN | PERCENT |
|---|---|---|---|
| Predator | 7 | 68 | 20.24 |
| Parasite | 0 | 0 | 0.00 |
| Collector-gatherer | 9 | 108 | 32.14 |
| Collector-filterer | 1 | 11 | 3.27 |
| Macrophyte-herbivore | 0 | 0 | 0.00 |
| Piercer-herbivore | 1 | 25 | 7.44 |
| Scraper | 4 | 106 | 31.55 |
| Shredder | 1 | 1 | 0.30 |
| Xylophage | 0 | 0 | 0.00 |
| Omnivore | 3 | 17 | 5.06 |
| Unknown | 0 | 0 | 0.00 |

RATIOS OF FFG ABUNDANCES

| | |
|---|---|
| Scraper/Collector-filterer | 9.64 |
| Scraper/(Scraper + C.filterer) | 0.91 |
| Shredder/Total organisms | 0.00 |

CONTRIBUTION OF DOMINANT TAXA

| TAXON | ABUNDANCE | PERCENT |
|---|---|---|
| *Glossosoma* sp. | 89 | 26.49 |
| *Drunella doddsi* | 32 | 9.52 |
| *Cricotopus nostococladius* | 25 | 7.44 |
| *Serratella tibialis* | 24 | 7.14 |
| *Drunella grandis* | 23 | 6.85 |
| SUBTOTAL 5 DOMINANTS | 193 | 57.44 |
| *Hexatoma* sp. | 23 | 6.85 |
| *Hesperoperla pacifica* | 19 | 5.65 |
| *Brachycentrus americanus* | 11 | 3.27 |
| *Hydropsyche* sp. | 11 | 3.27 |
| Atherix sp. | 11 | 3.27 |
| TOTAL DOMINANTS | 268 | 79.76 |

SAPROBIC INDICES

| | |
|---|---|
| Hilsenhoff Biotic Index | 2.00 |

DIVERSITY MEASURES

| | |
|---|---|
| Shannon H (loge) | 2.30 |
| Shannon H (log2) | 3.32 |
| Evenness | 0.71 |
| Simpson D | 0.10 |

COMMUNITY VOLTINISM ANALYSIS

| TYPE | ABUNDANCE | PERCENT |
|---|---|---|
| Multivoltine | 39 | 11.53 |
| Univoltine | 253 | 75.22 |
| Semivoltine | 45 | 13.24 |

| | #TAXA | ABUNDANCE | PERCENT |
|---|---|---|---|
| Tolerant | 2 | 6 | 1.79 |
| Intolerant | 3 | 63 | 18.75 |
| Clinger | 13 | 220 | 65.48 |

**Aquatic Invertebrate Taxonomic Data**

**Site Name: Gallatin River**
**Site ID: G-4 8/22/2000**

Approx. percent of sample used: 17

| **Taxon** | **Quantity** | **Percent** | **HBI** | **FFG** |
|---|---|---|---|---|
| *Nais* sp. | 2 | 0.66 | 8 | CG |
| Tubificidae - immature | 3 | 0.98 | 9 | CG |
| **Total Misc. Taxa** | **5** | **1.64** | | |
| *Acentrella turbida* | 1 | 0.33 | 4 | CG |
| *Baetis tricaudatus* | 8 | 2.62 | 6 | CG |
| *Drunella grandis* | 6 | 1.97 | 2 | CG |
| *Serratella tibialis* | 7 | 2.30 | 2 | CG |
| *Epeorus albertae* | 1 | 0.33 | 1 | SC |
| *Ameletus* sp. | 1 | 0.33 | 0 | CG |
| **Total Ephemeroptera** | **24** | **7.87** | | |
| *Hesperoperla pacifica* | 2 | 0.66 | 2 | PR |
| *Cultus* sp. | 2 | 0.66 | 2 | PR |
| *Pteronarcys californica* | 1 | 0.33 | 1 | OM |
| **Total Plecoptera** | **5** | **1.64** | | |
| *Arctopsyche grandis* | 3 | 0.98 | 1 | PR |
| *Brachycentrus americanus* | 1 | 0.33 | 1 | OM |
| *Brachycentrus occidentalis* | 4 | 1.31 | 1 | OM |
| *Glossosoma* sp. | 153 | 50.16 | 1 | SC |
| *Hydropsyche* sp. | 12 | 3.93 | 4 | CF |
| **Total Trichoptera** | **173** | **56.72** | | |
| *Atherix* sp. | 2 | 0.66 | 4 | PR |
| *Simulium* sp. | 1 | 0.33 | 6 | CF |
| *Hexatoma* sp. | 5 | 1.64 | 2 | PR |
| **Total Diptera** | **8** | **2.62** | | |
| *Cricotopus nostococladius* | 2 | 0.66 | 3 | PH |
| Eukiefferiella Brehmi Gr. | 4 | 1.31 | 4 | OM |
| Eukiefferiella Devonica Gr. | 14 | 4.59 | 4 | OM |
| Eukiefferiella Pseudomontana Gr. | 1 | 0.33 | 8 | OM |
| *Orthocladius* sp. | 62 | 20.33 | 6 | CG |
| *Pagastia* sp. | 3 | 0.98 | 1 | CG |
| *Rheotanytarsus* sp. | 1 | 0.33 | 6 | CF |
| *Tvetenia* sp. | 3 | 0.98 | 5 | CG |
| **Total Chironomidae** | **90** | **29.51** | | |
| **Grand Total** | **305** | **100.00** | | |

**Aquatic Invertebrate Summary Data**

**Site Name: Gallatin River** **Site ID: G-4 8/22/2000**

| | |
|---|---|
| TOTAL ABUNDANCE | 305 |
| Ephemeroptera + Plecoptera + Trichoptera (EPT) abundance | 202 |
| TOTAL NUMBER OF TAXA | 27 |
| Number EPT taxa | 14 |

TAXONOMIC GROUP COMPOSITION

| GROUP | #TAXA | ABUNDAN | PERCENT |
|---|---|---|---|
| Misc. Taxa | 2 | 5 | 1.64 |
| Odonata | 0 | 0 | 0.00 |
| Ephemeroptera | 6 | 24 | 7.87 |
| Plecoptera | 3 | 5 | 1.64 |
| Hemiptera | 0 | 0 | 0.00 |
| Megaloptera | 0 | 0 | 0.00 |
| Trichoptera | 5 | 173 | 56.72 |
| Lepidoptera | 0 | 0 | 0.00 |
| Coleoptera | 0 | 0 | 0.00 |
| Diptera | 3 | 8 | 2.62 |
| Chironomidae | 8 | 90 | 29.51 |

RATIOS OF TAX GROUP ABUNDANCES

| | |
|---|---|
| EPT/Chironomidae | 2.24 |

FUNCTIONAL FEEDING GROUP (FFG) COMPOSITION

| GROUP | #TAXA | ABUNDAN | PERCENT |
|---|---|---|---|
| Predator | 5 | 14 | 4.59 |
| Parasite | 0 | 0 | 0.00 |
| Collector-gatherer | 10 | 96 | 31.48 |
| Collector-filterer | 3 | 14 | 4.59 |
| Macrophyte-herbivore | 0 | 0 | 0.00 |
| Piercer-herbivore | 1 | 2 | 0.66 |
| Scraper | 2 | 154 | 50.49 |
| Shredder | 0 | 0 | 0.00 |
| Xylophage | 0 | 0 | 0.00 |
| Omnivore | 6 | 25 | 8.20 |
| Unknown | 0 | 0 | 0.00 |

RATIOS OF FFG ABUNDANCES

| | |
|---|---|
| Scraper/Collector-filterer | 11.00 |
| Scraper/(Scraper + C.filterer) | 0.92 |
| Shredder/Total organisms | 0.00 |

CONTRIBUTION OF DOMINANT TAXA

| TAXON | ABUNDANCE | PERCENT |
|---|---|---|
| *Glossosoma* sp. | 153 | 50.16 |
| *Orthocladius* sp. | 62 | 20.33 |
| Eukiefferiella Devonica Gr. | 14 | 4.59 |
| *Hydropsyche* sp. | 12 | 3.93 |
| *Baetis tricaudatus* | 8 | 2.62 |
| SUBTOTAL 5 DOMINANTS | 249 | 81.64 |
| *Serratella tibialis* | 7 | 2.30 |
| *Drunella grandis* | 6 | 1.97 |
| *Hexatoma* sp. | 5 | 1.64 |
| *Brachycentrus occidentalis* | 4 | 1.31 |
| TOTAL DOMINANTS | 271 | 88.85 |

SAPROBIC INDICES

| | |
|---|---|
| Hilsenhoff Biotic Index | 2.77 |

DIVERSITY MEASURES

| | |
|---|---|
| Shannon H (loge) | 1.88 |
| Shannon H (log2) | 2.71 |
| Evenness | 0.57 |
| Simpson D | 0.30 |

COMMUNITY VOLTINISM ANALYSIS

| TYPE | ABUNDANCE | PERCENT |
|---|---|---|
| Multivoltine | 77 | 25.33 |
| Univoltine | 217 | 71.07 |
| Semivoltine | 11 | 3.61 |

| | #TAXA | ABUNDANCE | PERCENT |
|---|---|---|---|
| Tolerant | 2 | 9 | 2.95 |
| Intolerant | 2 | 4 | 1.31 |
| Clinger | 12 | 192 | 62.95 |

**Aquatic Invertebrate Taxonomic Data**

**Site Name: Gallatin River**

**Site ID: G-5 8/22/2000**

Approx. percent of sample used: 17

| **Taxon** | **Quantity** | **Percent** | **HBI** | **FFG** |
|---|---|---|---|---|
| *Nais* sp. | 1 | 0.33 | 8 | CG |
| Tubificidae - immature | 6 | 1.96 | 9 | CG |
| *Acari* | 1 | 0.33 | 5 | PA |
| **Total Misc. Taxa** | **8** | **2.61** | | |
| *Acentrella turbida* | 4 | 1.31 | 4 | CG |
| *Baetis bicaudatus* | 41 | 13.40 | 4 | CG |
| *Drunella doddsi* | 28 | 9.15 | 0 | CG |
| *Drunella grandis* | 3 | 0.98 | 2 | CG |
| *Serratella tibialis* | 10 | 3.27 | 2 | CG |
| *Rhithrogena* sp. | 5 | 1.63 | 0 | SC |
| **Total Ephemeroptera** | **91** | **29.74** | | |
| *Sweltsa* sp. | 4 | 1.31 | 1 | PR |
| *Despaxia augusta* | 1 | 0.33 | 0 | SH |
| *Doroneuria* sp. | 1 | 0.33 | 1 | PR |
| *Hesperoperla pacifica* | 22 | 7.19 | 2 | PR |
| *Skwala* sp. | 3 | 0.98 | 2 | PR |
| *Pteronarcys californica* | 4 | 1.31 | 1 | OM |
| **Total Plecoptera** | **35** | **11.44** | | |
| *Arctopsyche grandis* | 13 | 4.25 | 1 | PR |
| *Brachycentrus americanus* | 1 | 0.33 | 1 | OM |
| *Brachycentrus occidentalis* | 1 | 0.33 | 1 | OM |
| *Glossosoma* sp. | 41 | 13.40 | 1 | SC |
| *Hydropsyche* sp. | 11 | 3.59 | 4 | CF |
| **Total Trichoptera** | **67** | **21.90** | | |
| *Optioservus* sp. | 3 | 0.98 | 4 | SC |
| **Total Coleoptera** | **3** | **0.98** | | |
| *Atherix* sp. | 14 | 4.58 | 4 | PR |
| *Simulium* sp. | 6 | 1.96 | 6 | CF |
| *Hexatoma* sp. | 14 | 4.58 | 2 | PR |
| **Total Diptera** | **34** | **11.11** | | |
| *Cardiocladius* sp. | 1 | 0.33 | 5 | PR |
| *Cricotopus brevipalpus* | 1 | 0.33 | 7 | CG |
| *Cricotopus nostococladius* | 47 | 15.36 | 3 | PH |
| Eukiefferiella Gracei Gr. | 1 | 0.33 | 4 | OM |
| *Micropsectra* sp. | 3 | 0.98 | 7 | CG |
| *Orthocladius* sp. | 13 | 4.25 | 6 | CG |
| *Pagastia* sp. | 1 | 0.33 | 1 | CG |
| *Tvetenia* sp. | 1 | 0.33 | 5 | CG |
| **Total Chironomidae** | **68** | **22.22** | | |
| **Grand Total** | **306** | **100.00** | | |

**Aquatic Invertebrate Summary Data**

**Site Name: Gallatin River** **Site ID: G-5 8/22/2000**

| | |
|---|---|
| TOTAL ABUNDANCE | 306 |
| Ephemeroptera + Plecoptera + Trichoptera (EPT) abundance | 193 |
| TOTAL NUMBER OF TAXA | 32 |
| Number EPT taxa | 17 |

TAXONOMIC GROUP COMPOSITION

| GROUP | #TAXA | ABUNDAN | PERCENT |
|---|---|---|---|
| Misc. Taxa | 3 | 8 | 2.61 |
| Odonata | 0 | 0 | 0.00 |
| Ephemeroptera | 6 | 91 | 29.74 |
| Plecoptera | 6 | 35 | 11.44 |
| Hemiptera | 0 | 0 | 0.00 |
| Megaloptera | 0 | 0 | 0.00 |
| Trichoptera | 5 | 67 | 21.90 |
| Lepidoptera | 0 | 0 | 0.00 |
| Coleoptera | 1 | 3 | 0.98 |
| Diptera | 3 | 34 | 11.11 |
| Chironomidae | 8 | 68 | 22.22 |

RATIOS OF TAX GROUP ABUNDANCES

| | |
|---|---|
| EPT/Chironomidae | 2.84 |

FUNCTIONAL FEEDING GROUP (FFG) COMPOSITION

| GROUP | #TAXA | ABUNDAN | PERCENT |
|---|---|---|---|
| Predator | 8 | 72 | 23.53 |
| Parasite | 1 | 1 | 0.33 |
| Collector-gatherer | 12 | 112 | 36.60 |
| Collector-filterer | 2 | 17 | 5.56 |
| Macrophyte-herbivore | 0 | 0 | 0.00 |
| Piercer-herbivore | 1 | 47 | 15.36 |
| Scraper | 3 | 49 | 16.01 |
| Shredder | 1 | 1 | 0.33 |
| Xylophage | 0 | 0 | 0.00 |
| Omnivore | 4 | 7 | 2.29 |
| Unknown | 0 | 0 | 0.00 |

RATIOS OF FFG ABUNDANCES

| | |
|---|---|
| Scraper/Collector-filterer | 2.88 |
| Scraper/(Scraper + C.filterer) | 0.74 |
| Shredder/Total organisms | 0.00 |

CONTRIBUTION OF DOMINANT TAXA

| TAXON | ABUNDANCE | PERCENT |
|---|---|---|
| *Cricotopus nostococladius* | 47 | 15.36 |
| *Baetis bicaudatus* | 41 | 13.40 |
| *Glossosoma* sp. | 41 | 13.40 |
| *Drunella doddsi* | 28 | 9.15 |
| *Hesperoperla pacifica* | 22 | 7.19 |
| SUBTOTAL 5 DOMINANTS | 179 | 58.50 |
| *Atherix* sp. | 14 | 4.58 |
| *Hexatoma* sp. | 14 | 4.58 |
| *Arctopsyche grandis* | 13 | 4.25 |
| *Orthocladius* sp. | 13 | 4.25 |
| Hydropsyche sp. | 11 | 3.59 |
| TOTAL DOMINANTS | 244 | 79.73 |

SAPROBIC INDICES

| | |
|---|---|
| Hilsenhoff Biotic Index | 2.70 |

DIVERSITY MEASURES

| | |
|---|---|
| Shannon H (loge) | 2.44 |
| Shannon H (log2) | 3.51 |
| Evenness | 0.70 |
| Simpson D | 0.08 |

COMMUNITY VOLTINISM ANALYSIS

| TYPE | ABUNDANCE | PERCENT |
|---|---|---|
| Multivoltine | 89 | 28.92 |
| Univoltine | 173 | 56.37 |
| Semivoltine | 45 | 14.71 |

| | #TAXA | ABUNDANCE | PERCENT |
|---|---|---|---|
| Tolerant | 1 | 3 | 0.98 |
| Intolerant | 5 | 118 | 38.56 |
| Clinger | 13 | 127 | 41.50 |

**Aquatic Invertebrate Taxonomic Data**

**Site Name: Gallatin River**

**Site ID: G-6 8/22/2000**

Approx. percent of sample used: 37

| Taxon | Quantity | Percent | HBI | FFG |
|---|---|---|---|---|
| *Acari* | 3 | 0.98 | 5 | PA |
| **Total Misc. Taxa** | **3** | **0.98** | | |
| *Acentrella turbida* | 20 | 6.56 | 4 | CG |
| *Baetis tricaudatus* | 16 | 5.25 | 6 | CG |
| *Attenella margarita* | 1 | 0.33 | 2 | CG |
| *Drunella doddsi* | 18 | 5.90 | 0 | CG |
| *Drunella grandis* | 3 | 0.98 | 2 | CG |
| *Serratella tibialis* | 22 | 7.21 | 2 | CG |
| *Epeorus albertae* | 1 | 0.33 | 1 | SC |
| *Rhithrogena* sp. | 12 | 3.93 | 0 | SC |
| **Total Ephemeroptera** | **93** | **30.49** | | |
| *Sweltsa* sp. | 2 | 0.66 | 1 | PR |
| *Doroneuria* sp. | 1 | 0.33 | 1 | PR |
| *Hesperoperla pacifica* | 23 | 7.54 | 2 | PR |
| *Cultus* sp. | 5 | 1.64 | 2 | PR |
| *Pteronarcys californica* | 7 | 2.30 | 1 | OM |
| **Total Plecoptera** | **38** | **12.46** | | |
| *Arctopsyche grandis* | 17 | 5.57 | 1 | PR |
| *Brachycentrus occidentalis* | 4 | 1.31 | 1 | OM |
| *Glossosoma* sp. | 72 | 23.61 | 1 | SC |
| *Hydropsyche* sp. | 4 | 1.31 | 4 | CF |
| *Rhyacophila* sp.-early instar | 1 | 0.33 | 0 | PR |
| **Total Trichoptera** | **98** | **32.13** | | |
| *Zaitzevia* sp. | 1 | 0.33 | 4 | CG |
| **Total Coleoptera** | **1** | **0.33** | | |
| *Atherix* sp. | 12 | 3.93 | 4 | PR |
| *Clinocera* sp. | 1 | 0.33 | 6 | PR |
| *Simulium* sp. | 9 | 2.95 | 6 | CF |
| *Antocha* sp. | 1 | 0.33 | 3 | CG |
| *Hexatoma* sp. | 5 | 1.64 | 2 | PR |
| **Total Diptera** | **28** | **9.18** | | |
| *Cardiocladius* sp. | 2 | 0.66 | 5 | PR |
| *Cricotopus nostococladius* | 5 | 1.64 | 3 | PH |
| Eukiefferiella Devonica Gr. | 4 | 1.31 | 4 | OM |
| Eukiefferiella Gracei Gr. | 11 | 3.61 | 4 | OM |
| *Micropsectra* sp. | 8 | 2.62 | 7 | CG |
| *Orthocladius* sp. | 12 | 3.93 | 6 | CG |
| *Pagastia* sp. | 1 | 0.33 | 1 | CG |
| *Tvetenia* sp. | 1 | 0.33 | 5 | CG |
| **Total Chironomidae** | **44** | **14.43** | | |
| **Grand Total** | **305** | **100.00** | | |

**Aquatic Invertebrate Summary Data**

**Site Name: Gallatin River** **Site ID: G-6 8/22/2000**

| | |
|---|---|
| TOTAL ABUNDANCE | 305 |
| Ephemeroptera + Plecoptera + Trichoptera (EPT) abundance | 229 |
| TOTAL NUMBER OF TAXA | 33 |
| Number EPT taxa | 18 |

TAXONOMIC GROUP COMPOSITION

| GROUP | #TAXA | ABUNDAN | PERCENT |
|---|---|---|---|
| Misc. Taxa | 1 | 3 | 0.98 |
| Odonata | 0 | 0 | 0.00 |
| Ephemeroptera | 8 | 93 | 30.49 |
| Plecoptera | 5 | 38 | 12.46 |
| Hemiptera | 0 | 0 | 0.00 |
| Megaloptera | 0 | 0 | 0.00 |
| Trichoptera | 5 | 98 | 32.13 |
| Lepidoptera | 0 | 0 | 0.00 |
| Coleoptera | 1 | 1 | 0.33 |
| Diptera | 5 | 28 | 9.18 |
| Chironomidae | 8 | 44 | 14.43 |

RATIOS OF TAX GROUP ABUNDANCES

| | |
|---|---|
| EPT/Chironomidae | 5.20 |

FUNCTIONAL FEEDING GROUP (FFG) COMPOSITION

| GROUP | #TAXA | ABUNDAN | PERCENT |
|---|---|---|---|
| Predator | 10 | 69 | 22.62 |
| Parasite | 1 | 3 | 0.98 |
| Collector-gatherer | 12 | 104 | 34.10 |
| Collector-filterer | 2 | 13 | 4.26 |
| Macrophyte-herbivore | 0 | 0 | 0.00 |
| Piercer-herbivore | 1 | 5 | 1.64 |
| Scraper | 3 | 85 | 27.87 |
| Shredder | 0 | 0 | 0.00 |
| Xylophage | 0 | 0 | 0.00 |
| Omnivore | 4 | 26 | 8.52 |
| Unknown | 0 | 0 | 0.00 |

RATIOS OF FFG ABUNDANCES

| | |
|---|---|
| Scraper/Collector-filterer | 6.54 |
| Scraper/(Scraper + C.filterer) | 0.87 |
| Shredder/Total organisms | 0.00 |

CONTRIBUTION OF DOMINANT TAXA

| TAXON | ABUNDANCE | PERCENT |
|---|---|---|
| *Glossosoma* sp. | 72 | 23.61 |
| *Hesperoperla pacifica* | 23 | 7.54 |
| *Serratella tibialis* | 22 | 7.21 |
| *Acentrella turbida* | 20 | 6.56 |
| *Drunella doddsi* | 18 | 5.90 |
| SUBTOTAL 5 DOMINANTS | 155 | 50.82 |
| *Arctopsyche grandis* | 17 | 5.57 |
| *Baetis tricaudatus* | 16 | 5.25 |
| *Rhithrogena* sp. | 12 | 3.93 |
| *Atherix* sp. | 12 | 3.93 |
| Orthocladius sp. | 12 | 3.93 |
| TOTAL DOMINANTS | 224 | 73.44 |

SAPROBIC INDICES

| | |
|---|---|
| Hilsenhoff Biotic Index | 2.50 |

DIVERSITY MEASURES

| | |
|---|---|
| Shannon H (loge) | 2.51 |
| Shannon H (log2) | 3.63 |
| Evenness | 0.72 |
| Simpson D | 0.08 |

COMMUNITY VOLTINISM ANALYSIS

| TYPE | ABUNDANCE | PERCENT |
|---|---|---|
| Multivoltine | 64 | 20.98 |
| Univoltine | 188 | 61.48 |
| Semivoltine | 54 | 17.54 |

| | #TAXA | ABUNDANCE | PERCENT |
|---|---|---|---|
| Tolerant | 2 | 17 | 5.57 |
| Intolerant | 4 | 29 | 9.51 |
| Clinger | 17 | 179 | 58.69 |